DELAFIELD.

REPORT ON WATER SUPPLY IN NEW BRIGHTON, N.Y.

REPORT

ON THE

Water Supply

FOR THE

VILLAGE OF NEW BRIGHTON,

STATEN ISLAND.

BY

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New York:
CITY LAW AND JOB PRINTING OFFICE, 23 PARK ROW.

NEW BRIGHTON, STATEN ISLAND,
January 8, 1876.

To the Trustees of the Village of New Brighton :

GENTLEMEN :

The question of a water supply for the village of New Brighton, under the Holly system or otherwise, submitted to me by your board has been carefully considered, and I have collected from a large and valuable correspondence, the data to enable you to form an intelligent opinion by comparison, and from the positive statements of high professional authority.

I have considered not only the Holly system, but also the systems used under the gravitation methods, both from other pumps, as also in the case of successful boring on some point high enough to avoid the neceesity of pumping.

The Holly system, as it is termed, proposes to abolish both reservoir and stand pipe, and relies upon direct pumping through the distributing pipes, to enable it to fulfill the service, hence claims an economy in first cost of construction ; also, a capacity to produce pressure sufficient at any hydrant, at short notice, to be able to throw a stream of water for fire purposes, equivalent to a moveable fire-engine, thereby doing away with fire-engines and saving the cost of the same.

To determine the economy of construction, if we admit the source of water from a well to be the same, and the distribution pipes the same, it is evident that if we can save the first cost of a reservoir, say from $30,000 to $65,000, It is a very important gain ; but if we use a stand pipe costing $6,000, for any of the other standard pumps, the comparison is not so favorable.

For the purpose of such comparison, I have obtained the price of the pumps mentioned in the following table, and have also added the cost of stand pipe, to wit, $6,000, to enable them to be on an equality of pressure, with the Holly pump, each to be capable of delivering 2,000,000 gallons of water per diem of 24 hours. The price being for pumps, engines and boilers, but in no case including buildings and the necessary foundations.

Holly direct				27,000
Cornish,	$32,000	add stand	pipe,	38,000
Leavit,	20,000	"	"	26,000
Worthington	17,500	"	"	23,500
Knowles,	14,500	"	"	20,500

Of course, under competition, it is fair to say that any of the above pumps might be furnished for less price, but the above table exhibits Knowles pump as $12,500 less than Holly, or with stand pipe, $6,500 less.

The next comparison, is the dimension of a pump for the direct system, as against a pump for a reservoir. The direct pump requires capacity to pump for the usual domestic supply, and at the same time, the capacity to furnish the demand for five hydrants in case of a fire call. I assume the domestic use at the rate of 2,000,000 gallons of water per diem, at present, that amount having been suggested by Mr. Holly, as the capacity of the pump he offered for domestic supply, rather than the present need of the village. The domestic use per hour, at this rate, will be 83,000 gallons. If now a fire occurs, using five hydrants for one hour, under 150 feet head or pressure, there will be used 225,000 gallons, making a total demand on the pumps in one hour, of 308,000 gallons, or 7,392,000 gallons per diem. The dimension of pump required being equal to this capacity.

By the cumulative system of a reservoir, it is evident that the pumping of this extraordinary quantity for fire purposes, is distributed over, as the average distance in time of one fire from another, is in no case in a village less than a week apart, allowing a full week to pump the 225,000 gallons for such fire use, or 1,343 gallons per hour, which added to the domestic need, would require 2,032,232 gallons of water pumped per diem, as against the Holly capacity of 7,302,000 per diem capacity. Hence, the direct system requires pumps about three and one-half larger dimensions than the reservoir system.

The stand pipe, when 200 feet high and 5 feet diameter, contains 31,000 gallons, and is no substitute for a reservoir, being valued by engineers as a relief or safety valve to the pumps and distribution pipes, permitting the pulsation of the piston rotation pumps to be expended without strain. This stand pipe may be of any altitude required, hence the pressure of water may be made by this means equivalent to any given pressure of the direct system. The stand pipe, 200 feet high, gives a pressure of 80 lbs. per inch, which, I observe, is what is deemed the proper pressure for fire purposes in the prairie towns where the Holly system has been adopted. Of course our high grounds enable us to erect a stand pipe to produce any pressure required, at much less cost than in a flat prairie country.

The next question is economy of use. The following tests were made by the professional authorities, whose names are annexed, and given as fair results of best service in each case, the duty being the number of pounds raised one foot high, with 100 lbs. of coal consumed.

Name of Pump,	*Authority.*	*Duty.*
Holly, - -	S. E. Booth, Rochester, -	65,515,000
- -	F. H. Clement, " -	....
Cornish, - -	G. H. Bailey, Belleville, -	70,195,143
Leavitt, - -	Wm. E. Worthen, Lynn,	103,923,215
- -	J. C. Hoadley, - -	....
- -	James P. Kirkwood, -	....
- -	Chas. Hermany, - -	....
- -	Jos. P. Davis, - - -	....
Worthington,	G. H. Bailey, Newark, -	76,386,262

From the current reports of Commissioners of Water Works, or the Superintendents, I have obtained the following prices of work done in cost of fuel only, for raising one million gallons one foot high :

Holly,	Pump,	Columbus, O., - -	$22\frac{2}{10}$
do.	do.	Covington, Ky., - -	$26\frac{5}{10}$
do.	do.	Dayton, O., - - -	$47\frac{5}{10}$
do.	do.	Dunkirk, N.Y., - -	61
Cornish,	do.	Erie, Penn., - - -	$10\frac{5}{10}$
do.	do.	Roxboro, Phila., -	$12\frac{7}{20}$
do.	do.	Schuylkill, Phila., - -	$10\frac{9}{10}$
Worthington	do.	Bellmont, Phila., -	7
do.	do.	Newark, N. J., - -	8
do.	do.	Belleville, N.J., - -	8
do.	do.	Roxboro, Phila., - -	$9\frac{9}{10}$
Leavitt,	do.	Lynn. Mass., - -	$4\frac{15}{100}$

Assuming 1,000,000 gallons of water raised 140 feet high, and taking the best practice above, we have for cost of fuel per diem :

Holly a $22\frac{2}{10}$, - - - - - -	$33 30
Cornish a $10\frac{5}{10}$, - - - - - -	15 74
Worthington a 7, - - - - - -	10 50
Leavitt a $4\frac{15}{100}$, - - - - -	6 23

These exhibits of duty make it evident that under the Holly system a very low economical service must obtain, which I attribute, to some extent, to the necessity of fires being kept large enough for fire service, and dampened or throttled back for domestic service only, making a constant imperfect combustion or wastage of fuel, and as this item of fuel largely determines the profits or loss in the current running of water works, it is a most important factor in favor of one pump over another.

The cost of attendance is another item to be considered. In the direct system the attendance of an engineer, day and night, is imperative, as fires are liable to occur at any moment. For this reason two firemen are needed, as each engineer is not able to wheel in coal trim fires, etc., without taking him too far from fire duty. In any other system, the pumps may be large enough to run by day only, and the engineer has ample time to do his own firing, thus saving one engineer and two firemen, or, say $2,000 per annum. As all the pumps have been estimated capable of pumping two millions of gallons in 24 hours, it is evident that either pump could furnish the present demand ot one million gallons in twelve hours, giving this saving in attendance.

There is still another question of relative cost, impossible to determine without a knowledge of locality, to wit, the foundation. On a rock bottom, of course, all are alike, but in a morass or salt meadow, this question may become one of very serious import, costing many thousand dollars. The Cornish pump gives terrible service to its foundation; the Leavitt, also, is severe; the Holly, when running but one pump, is especially injurious. In this respect, the Worthington and Knowles pumps are decidedly superior, as they are self-contained, and have but little jar and less weight. Being unable to determine this cost, further discussion at this time would not be pertinent.

The strong argument used by friends of the Holly system is the value of the same for fire purposes. I have endeavored to obtain all the information I could upon this subject. The main point raised by those villages having the Holly system seems to be that, prior to having water works, they rarely saved a frame building when once fairly ignited, whereas now they save most buildings, and hence are entitled to large deductions of insurance, etc. It would seem as though this argument might as fairly be used with any system having a similar volume and pressure of water, as no one doubts that a full supply of water, convenient to a fire, is decidedly better than no water. The question of abolishing fire engines is urged by the friends of the direct system.

At a meeting of Fire Department Chiefs, Oct. 4, 1875, the committee on direct service supply, submitted in their report as follows: "From all the facts and opinions gathered, the committee are more than ever impressed with the superiority of the reservoir system over all others, and they think that only insurmountable financial or topographical difficulties should permit the introduction of any other in preference. While a large reservoir is preferable for *storage* purposes, it is not indispensable for fire uses. A comparatively small reservoir, placed at such moderate elevation as might be gained without great expense for stone or brick work, where no natural facilities exist, would supply all that is necessary for fire engines at fires. The amount drawn from the New York reservoir for fires is rarely so great as to be even perceptible. The advantages of any system that exerts a uniform pressure upon the distribution pipes must be obvious to all. In the proportion that the hours in a year, during which no conflagration is taking place, exceed the hours of such conflagration, any steady pressure is preferable to any irregular one. There may be found defects in the pipes under any system; but in cases of a constant or uniform pressure breakages are less likely to occur, and if they occur, the probability is very great in favor of their taking place at a time when the exigency of a fire is not coincident with the breaking.

"There are many other considerations in favor of a regular and constant pressure; but the committee regard it unnecessary to pursue that branch of the subject in any of its phases further.

"In the judgment of your committee no system of water supply justifies a reliance upon it to the exclusion of auxiliary moveable fire engines; and, least of all, does a direct service system justify such reliance. The contingencies which attach to systems generally, are still greater in regard to that system; but whether under that or any other, in the judgment of the committee, the members of this convention owe it to themselves to declare that no system can safely dispense with the aid of auxiliary moveable apparatus."

Committee:
Chief Battle, Detroit.
" Cronin, Washington.
" McFadden, Memphis.
" Gibson, Rochester.
And others.

It would seem from the experience of these gentlemen that we dare not save by dismissing any of our present engines; and as Messrs. Gibson and McFadden are both representatives of cities having the Holly system, we must give due weight to their opinion. Besides, the fact that parts of the village of New Brighton would be without hydrants, proves that there would be no possibility of such a course. The point raised in this report of Fire Chiefs, as to the undue strain upon the service pipes during fire, is one of great moment, and bears very hard upon house plumbing; also in case of the breakage of a main during this unusual strain, no pressure could be maintained upon the hydrants, and the whole system would be comparatively inert until it was repaired. In Binghamton, New York, a boiler belonging to the Holly pump exploded, and for a day the city was without protection from fire, or water to drink. Any boiler may, from abuse or hidden defect, place a city at this disadvantage. With a reservoir, in case of disaster to a pipe, the section can be cut off at once on both sides, and the circulation remain on all sides. In case of fire, the attachment of the suction hose of an engine to a hydrant would probably reduce the pressure in the service pipe, so that during this critical period of its use there is really less liability to accident, on account of reduced pressure. The assumption that Holly can produce greater pressure by pump than can be obtained by altitude from a reservoir, is wholly unfounded in fact, and really is the basis of the whole argument for use of the hydrants without fire engines ; and all the statements made in his pamphlet, in relation to the saving of property from fire, are made as against no water-works ; and as far as the use for firemen is concerned, the same number are needed for hose carts and the use of the hose. The question of friction in the service pipes is as much against the Holly system as against the gravitation system, and if the demand is for any given pressure, it is at once answered by the erection of a stand pipe of equivalent pressure from its altitude, or a reservoir of equal altitude.

We have, as a result of the foregoing examination—

First.—Holly's pump, engines and boilers cost $12,-500 more than Knowles' pump, etc.

Second.—Holly's pump, etc., costs $6,500 more than Knowles' pump, etc., with stand pipe.

Third.—A pump of Holly's pattern must, for his direct system and for fire use, be $3\frac{1}{2}$ times as large as a pump with reservoir for storage.

Fourth.—Holly's system of pumping costs for coal $5\frac{1}{2}$ times more than Leavitt's, by actual yearly test, or 3 times more than Worthington's.

Fifth.—Holly's system requires twice the constant attention that any storage system would, and will not permit a minute of inattention, hence requiring a first-rate order of men to attend it.

Sixth.—Holly needs heavy, expensive foundations—Worthington and Knowles' slight, by comparison.

Seventh.—Holly cannot possibly send a higher and larger stream from a hose than can be sent by means of the gravity system, and as every pipe and all house service is necessarily adapted to the greatest pressure, the service must be constructed alike. Hence, the constant, even pressure from the reservoir must be preferable for instant use in case of fire, and at such times easier to the service pipes than the waves of pressure delivered from the piston pumps.

Eighth.—The opinion of the Chief Engineers of various cities, and our rural area, will prevent us from selling the fire engines, and thus saving capital and cost by any system.

Ninth.—The fatal effect, in case of a radical break-down of pump, engine or boiler, or any important fracture of a main pipe, renders the direct system vastly inferior to the reservoir or storage system ; and as citizens gradually lose their wells and cisterns after the introduction of water works, any such break-down is a calamity little less serious than the loss of the air we breathe.

Being familiar with various pumps, I express the opinion that no rotative piston-pump can be continuous in its discharge as is evidenced by the water cards ; and that Holly's pump is not equal in this to the Worthington pump, which for heavy continuous work, I believe, to be superior to any other at present manufactured. The Leavitt pump, at Lynn, Mass., is the most desirable for economy of running, but requires much heavier foundations, and is more expensive in repairs.

From the foregoing reasons and conclusions, I recommend therefore, that the Holly system or direct system be not adopted.

In relation to the Holly pump, it is condemned in Buffalo, Ogdensburg, Memphis, Mineapolis, etc., and partially in Columbus, Dayton, and other places for the great cost of repairs.

Having considered the Holly system, in its bearings, as to economy and utility, I shall only return to it when considering the total cost of the water works, so as to place it fairly by comparison with the completed works.

I propose now, to consider the fundamental question of the source of water supply. This question has long been a study with me, and is a problem that will require some experiments, conducted with great care and intelligence to produce a successful result. From our insularity, we are precluded from bringing water from the hills of New Jersey. The peculiar topographical formation of the Island, makes it impossible within the limits of the village to find area for drainage of surface water, to store for use. The only area suggested, being the Silver Lake and Britton Ponds. This tributary drainage area is only $1\frac{87}{100}$ miles superficies. With an annual rainfall of 36 inches, only one-half can be saved from evaporation and soakage, leaving 18 inches, which on the above area yields 312,825,600 gallons of water, eqnivalent to 857,000 gallons per diem. This might do for the immediate present, but would soon prove inadequate; besides, as there are three popular grave yards adjacent, and draining into this territory, I would suggest the dismissal of thic proposition.

A second drainage area is found lying east of and emptying into the valley running from Graniteville to Bulls Head. This tributary area is $3\frac{12}{100}$ miles superficies, hence, would yield from the 18 inches of rain water saved 976,000,000 gallons of water per annum, or

2,674,000 per diem, a very fair supply for some time to come. This valley being nearly a water level, is now a miasmatic swamp. By digging a canal 20 feet deep, 10 feet wide on the bottom and slopes 2 feet horizontal to 1 foot vertical and 1 mile long, we could store 40,000,000 gallons of water, and as by constant pumping, the water would be in constant circulation, the adjacent territory would be drained and improved, a healthy body of pure water replacing the present sour stagnant bog.

The cost of such a canal would be about $55,000 including fee of land.

Messrs. Holly & Peterson, expressed their opinion that an abundance of water could be found upon reaching a strata of gravel, underlying the Snug Harbor property, at about tidewater level for the bottom of the well. This opinion was deduced from their experience at Long Island City. I do not agree that the geological formations are analogous, and as the covering earth is not impervious, the ever-increasing population would by means of cess-pools, privies, stables and pig-pens, gradually poison the water so as to create epidemics of the most virulent character. I feel assured that the quantity of water is limited to the area drained, and is inadequate in supply.

West of Port Richmond and Graniteville lies a sandy surface soil, under which again is a stratum of gravel that extends westward under the Sound into New Jersey for a long distance. This gravel is the storage reservoir for the drainage of an immense district. Springs break out at or near tide water in large numbers in Mariners Harbor. At Singers Factory, Elizabethport, the well that furnishes the factory, is sunk through this clay stratum to the gravel, and furnishes a large volume of water. I feel confident that an ample supply can be found in this region for pumping.

The geological formation is peculiar. From the Palisades, on the Hudson River, the trap rock is seen running in a southwesterly direction, gradually depressed as it passes under Bergen Hill, thence passing under Bergen Point and the Kill von Kull, emerging at the water side of Jewett's residence, Port Richmond, passing thence to the quarries at Graniteville, and from there dipping under the Fresh Kill, is lost sight of until discovered on the Raritan River, between Perth Amboy and New Brunswick. West of this line lies the white and blue clays of various depths, forming impervious strata, covering the water bearing gravel.

East of the line of trap described is another step of the same rock, noticed at Bergen Point, at Gunther's residence, but only found on the island, in digging wells just east of the Pond road.

Between the Pond and Mill road there is a depression of the rock, and wells forty feet in depth pass through a stratum of water proof clay into a stratum of gravel, the reservoir of drainage of the surface above of limited area, the water rising and falling with the rains, and often chalybeate in taste from the deposits of hematite iron in the hills above.

East of this line, at many points the Serpentine rock comes to the surface, and on Tod Hill rises to an altitude of about 370 feet above tide-water. Below the Serpentine rock should occur the carboniferous strata and old red sandstone, also the Silurian rock overlying the Gneiss and Granite. I believe that the Serpentine rock rests upon the Gneiss rock, the usual intermediate rock being absent, and the reason for this belief is that the Gneiss of New York City is observed dipping under the Bay, arising to form Robin's Reef, and extending West to the beacon opposite New Brighton, probabably passing under Staten Island at the same rate of dip.

As the result of observation of American and European engineers, the magnesian limestones are prolific water bearing rocks, and the primitive Gneiss liable to fissures and stratification leading from great distances and bearing water of great purity. The Granite from its freedom from fissures or strata, and irregular contour may form good basins, but rarely carries water far. Geology is by no means an exact science, as far as determining without experimental examination the probable strata or their watar bearing conditions, but the above mentioned conditions are an assistance in an intelligent consideration of the subject now under investigation.

I find by observation, that there is a series of admirable springs commencing at the famous Hessian Springs, near Lafayette and Brighton Avenues, below Silver Lake ; also the Bement boiling springs, then various lesser springs, to the large springs at the Four Corners or Constantz Brewery, and so on to the Willow Brook and down to Springville. I have estimated, and find the amount of water discharged is vastly in excess of any surface drainage on the higher grounds of the island adjacent, and am thus led to the belief that these springs arise from the rock below, and have their source on hills far distant.

Experience, from the history of the oldest boring for water, found in China, to the modern practice of France and England, illustrates the feasibility of finding an ample supply of water in both places, for the use of dense populations, therefore the most conservative engineer finds ample precedent for such practice, where the conditions of water bearing rock are present. These conditions do underlie certain portions of the island, and from the positive proof of the springs mentioned, I believe that by boring on ground properly selected adjacent to some of the larger springs mentioned that water in ample quantities could be found, and if such bore is upon ground as high as the Constanz Brewery, and that water should flow in sufficient volume from this altitude of the Brewery spring, then the expense of pumping would be saved, and the altitude of 240 feet above tide as a head would be ample for all points of the village except the unoccupied grounds of the late John C. Green, adjacent to Messrs. Duncan and Cisco on the Richmond Turnpike.

As there is a spring immediately on the top of Tod Hill, 370 feet above tidewater, I infer the source is the same as the Brewery spring, and exhibits a very high fountain head.

But should a bore on this high ground demonstrate that a lower level should be sought, and pumping become necessary, it is evident that every foot in altitude gained for locating the pump is an economy in cost of pumping, and if the Hessian or Bement spring should prove a proper level to bore from, at least 100 feet altitude is gained, and from proximity to the system of distribution pipes, a saving in cost of mains, as against the distant wells of Graniteville or Mariners Harbor would be made, also being adjacent to higher ground, 140 feet above tide, would be conveniently located for pumping into a reservoir.

The cost of boring as now common in New Jersey and Pennsylvania with the diamond drill, is about $6 per foot for the first one hundred feet, and one dollar per foot additional in an arithmetical proportion for each succeeding one hundred feet.

I estimate the magnesian limestone as 350 feet thick, it rarely ever averages over 300 feet. If water should be found at this depth the cost for six-inch hole would be

100 feet,	- - - - -	$600
Second 100 "	- - - - -	700
Third 100 "	- - - - -	800
Fourth 50 "	- - - - -	450
Total 350 feet,	- - - - -	$2,560

This depth would, no doubt, be ample for the lower position in case of pumping. But for a test bore on high ground I would advise that not less than one thousand feet should be tested, unless ample supply was discovered sooner. A bore of this depth would search down into the strata and fissures of the Gneiss rock, and would finally settle the question of the value of an artesian well at this Island. The cost would not exceed $10,000, and I would desire to have this tested first, for the sake of economy, in case of success in finding water, and if not able to find water at such altitude, to determine the utility of seeking lower grounds indicated west or south of Port Richmond. In case the highest ground should be successful, the long mains between bore and distribution system of pipes would be ample as a reservoir to equalize the unequal demand of water in common use, as such main 15 inches diameter would contain in one mile 60,000 gallons. But for fire use it would be desirable to have a reservoir of capacity, say, equivalent to fire demand of 260,000 gallons, which would cost, say $2,000.

The purity of water for use in domestic affairs is one to be determined by a competent chemist, as it is possible to find water by any method, unfit for use. The water from deep bores, especially from the primitive rock formations, is usually found most free from foreign substances. Surface drainage stored in catchwater basins is apt to acquire most vegetable matter in solution. Water from gravel strata under clay formations is most likely to have large traces of salts of the earthy bases, and be a hard water. But water liable to receive by direct drainage or filtration, the excreta of animals from either cesspools, water-closets or barn yards, can not be too carefully excluded from domestic use, and is nearly certain to lead to fatal results.

Water with decaying vegetable matter is liable to produce periodic diseases, and wells in the low lands are often sources of this poison. These poisons may all be so diluted as to be impossible to detect except by the delicate tests of the chemist. In fact, water absolutely poisonous from any of the foregoing objectionable causes, may be more desirable to the eye, or grateful to the sense of taste, than absolutely pure, distilled water. Many wells on the Island are highly improper for use, and when tested with a drop of nitrate of silver solution exhibit a white cloudy reaction. This is either the chloride of sodium, or calcium, or magnesium, and is largely the cause, in the case of chloride of calcium, of the kidney and bladder difficulties so prevalent. The present cisterns are by no means agreeable, as in the populous neighborhoods the roofs of houses are covered with the dust of streets, partly composed of the excreta of animals using the same. The air is contaminated with the gases of decaying animal and vegetable matter, that saturates the falling rain, and is carried into the cisterns, where were no filters used, the water would soon exhibit a foul mass. The supply by this method soon proves inadequate in dense populations, and already in portions of New Brighton large sums are expended for hauling water.

The sources and modes of supply being considered, the distribution is next to be considered. I have examined the various streets, and have selected such as seemed to be probable from population to prove remunerative, and have included some alone for the purpose of circulation, so that in case of needed repairs the system could be in use on either side of the repairs. I find necessary, as follows :

15,900	feet 12-inch main pipe,	$2.80	- -	$40,420
1,700	" 8 " " "	1.85	- -	37,145
34,200	" 6 " " "	1.27	- -	43,434
32,800	" 4 " " "	83	- -	27,224
13,500	" 2 " " "	40	- -	5,400
98,100	" Total, or 18,58–100 miles		- -	119,722
	Add 144 Hydrants, at $60.00		- -	8,640
				$128,363

The prices are for pipe laid, and include all labor, material, gates, joints, four ways, etc., and is approximate, but safe, and sufficiently near to estimate the rest of the work as a whole. I have estimated on cast iron pipes, but advise the use of the iron pipe lined and encased in cement, as having been used for over twenty-five years with success in a large number of towns, costing less in first outlay, delivering the water as pure as from the source, and avoiding the loss of calibre found in cast pipes, arising from tubercles and incrustations due to chemical action of some waters on iron. As the cement is practically indestructible, the pipes are, as now made, capable of enduring for any time.

The question of income is one very difficult to estimate satisfactorily, and each person may honestly widely differ in anticipating a result. I have counted the houses of various sorts, and find on the line of pipes as proposed 859 dwellings and stores. I have assumed that as a well costs at least an average of $100, no man should decline to pay the interest of $7.00 for the use of water carried to him, and make this charge the lowest. The other charges I have adopted after examining various cards of water rates sent to me from various localities. The amounts are as follows :

240	Private Dwellings,	*a* $7.00	- - -	$1,680
150	do. do.	*a* 10.00	- - -	1,500
150	do. do.	*a* 15.00	- - -	2,250
50	do. do.	*a* 25.00	- - -	1,250
10	do. do.	*a* 50.00	- - -	500
3	Hotels,	*a*500.00	- - -	1,500
5	Livery Stables,	*a* 26.00	- - -	125
3	Bakers,	*a* 25.00	- - -	75
110	Stores and Saloons,	*a* 10.00	- - -	1,100
2	Factories,	*a*250.00	- - -	500
U. S. Lighthouse Department,			- - -	280
American Docks,			- - - - - -	500
Building purposes,			- - - - - -	500
				$11,730

To be sure, I shall assume as a basis of income $10,-000 in making the estimates of current profits or loss.

For the purpose of presenting the first cost of the various methods suggested, I have prepared the following tables, the price of land for reservoir or canal having been included in the estimate for the same before:

	Land for Pump & Well.	Boring.	Well & Buildings.	Pump.	Stand Pipe.	Reservoir or Canal.	Main Pipe.	Distributing Pipe.
Artesian Well........................	1,000	10,000	1,000	....	....	....	17,500	128,500
Artesian Well, with Pump, etc.........	10,000	2,500	2,500	17,500	6,000	....	3,000	128,500
Artesian Well, with Pump, Reservoir, etc.	10,000	2,500	2,500	17,500	....	65,000	6,000	128,500
Well at Mariner's Harbor, Stand Pipe....	5,000	....	7,500	17,500	6,000	....	35,000	128,500
Well at Mariner's Harbor, Reservoir.....	5,000	....	7,500	17,500	....	65,000	35,000	128,500
Canal at Graniteville and Stand Pipe....	1,000	....	7,500	17,500	6,000	55,000	20,000	128,500

The total cost of each is as follows:

Artesian Well - - - - - - - - - -	$158,000
do. do., with Pump, etc. - - - - - - - -	170,000
do. do., with Reservoir, etc. - - - - - - -	232,000
Well at Mariner's Harbor, Standpipe, - - - - - - - -	199,000
do. do., with Reservoir, - - - - - - - -	257,500
Canal at Graniteville, - - - - - - - - - -	235,500

The next question is to determine the cost of using the water works. This cost is made up of interest on use of capital, fuel, labor, superintendence and contingencies. In tabulating these I have taken the Holly system for comparison with the Worthington Pump and stand-pipe at Mariner's Harbor, assuming the cost to be the same, though really larger for the Holly system:

	Interest on cost at 7 per centum	Fuel for full service.	Engines.	Stokers.	Superin-tend'nce and con-t'gencies	Cost per Annum.
Artesian Well	11,060	..	..	....	2,500	13,560
Artesian Well, with pump and stand-pipe	11,900	3,800	2,000	....	5,000	22,700
Artesian Well, with reservoir, etc.	16,240	3,800	1,200	....	5,000	26,240
Well at Mariner's Harbor, Holly system	13,965	12,154	2,000	1,000	5,000	34,119
Well at Mariner's Harbor, stand-pipe system	13,965	3,800	2,000	....	5,000	24,765
Well at Mariner's Harbor, reservoir.	18,025	3,800	1,200	....	5,000	28,025
Canal at Graniteville, stand-pipe system	16,485	3,800	2,000	....	5,000	27,285

It is evident that from the above exhibit of cost of running each or any method there would be a deficit to make up if the income was $10,000 as estimated. If therefore, we deduct the income from the receipts, this deficit should be charged to the territory having the hydrants for fire purposes, as this would avoid taxing that portion of the village deriving no benefit from the same. As there is 98,000 feet of piping, there would be 196,000 of frontage within reach of the hydrants, and each building lot would be benefited by the possibility of the use of water for a residence, and be enhanced in value. The following table exhibits the deficit tax per front foot for the fire or hydrant use in each system :

	Deficit.	Tax front foot.
Artesian Well....................	3,560	1 82-100
Artesian Well, Pump and Standpipe	12.700	6 48-100
Artesian Well, Pump and Reservoir	16,240	8 28-100
Well at Mariner's Harbor, and Holly System..................	24,119	12 30-100
Well at Mariner's Harbor, and Standpipe....................	14,765	7 53-100
Well at Mariner's Harbor, and Reservoir.....................	18,025	9 20-100
Canal at Graniteville.............	17,285	8 82-100

From the foregoing views I would earnestly recommend a test bore on Tod Hill. The knowledge gained even if not successful, would be valuable as to determining the other problems of location. But, in case of success, a perpetual saving would be made.

I have avoided any calculations based on supply of water for the adjacent villages of Port Richmond and Edgewater, as this proposition has not been laid before me. I would suggest, however that, their interest being common in this matter, joint action would lighten the pro rata of first cost, and also lighten the deficit tax for hydrants.

Respectfully submitted,

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